



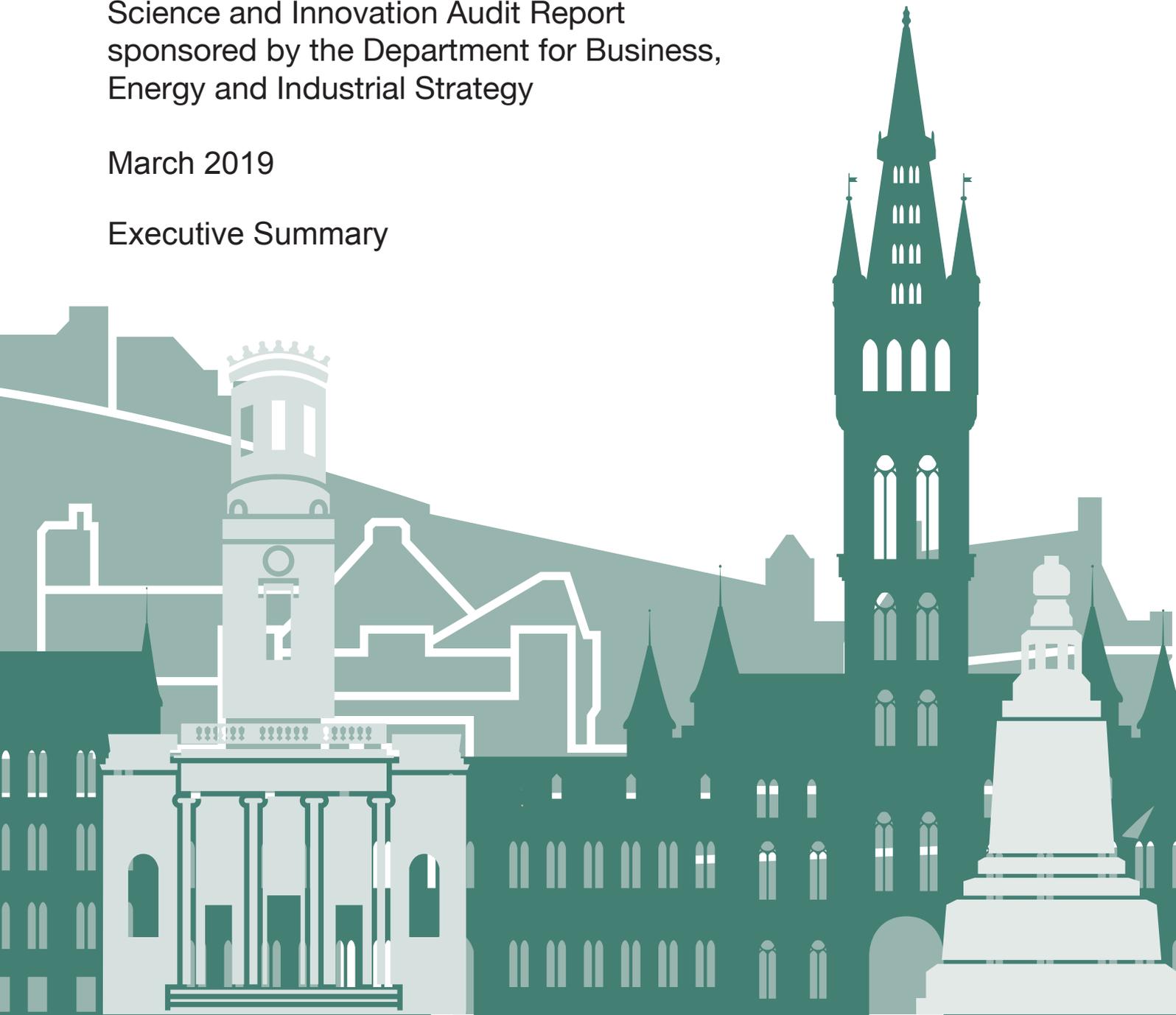
Department for
Business, Energy
& Industrial Strategy

Precision Medicine Innovation in Scotland: Accelerating Productivity Growth for Scotland and the UK

Science and Innovation Audit Report
sponsored by the Department for Business,
Energy and Industrial Strategy

March 2019

Executive Summary



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The University of Glasgow has been privileged to lead this important Science & Innovation Audit for Scotland, on behalf of the UK Department of Business, Energy and Industrial Strategy.



We would like to thank the following organisations and businesses for their valuable input and enthusiastic support. We are also grateful to SQW for supporting the Science & Innovation Audit through rigorous quantitative and qualitative research, allowing us to showcase the breadth and depth of Scotland's strengths and opportunities in Precision Medicine.

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“The adoption of precision medicine has the potential to be transformative for the people in Scotland, through improved diagnostics and patient treatment. That is why precision medicine has been a priority for the Scottish Government for more than five years, and I am pleased that this Science and Innovation Audit (SIA) recognises the many strengths and capabilities Scotland has in this field.



The Scottish life sciences industry is hugely significant for Scotland and, through the further development and adoption of precision medicine, is well placed to be an international leader in precision medicine technologies, products and services that can be exported around the world. This is supported by the world-class Imaging Centre of Excellence at the Queen Elizabeth University Hospital (QEUH) campus in Glasgow which is pioneering the use of precision medicine to develop new treatments for patients facing serious conditions such as strokes, brain tumours, multiple sclerosis and dementia. The Centre is also attracting academics and businesses to relocate from elsewhere in Europe to be based here, as part of this world-leading beacon of science and innovation. As recognised by the consortium behind this SIA, the campus has the potential to become an important hub for an emerging precision medicine cluster for Scotland.

Whilst the SIA consortium has been led by the University of Glasgow, the process has very much been characterised by a genuine ‘Team Scotland’ approach, with support, commitment and real insight from industry, academia and the NHS across Scotland. This is another positive example of collaborative working in Scotland which reinforces our commitment to world class research and innovation, supporting advances in health care, improved patient outcomes and sustainable economic growth.”

Nicola Sturgeon MSP, First Minister of Scotland

In today's society, individuals are living longer, resulting in an ageing population which is also affected by multi-morbidities. New innovative treatments, e.g. cancer therapies, are available but are expensive to produce and are not effective for all, and the rising costs of medicines is becoming increasingly unaffordable to healthcare systems across the world. Precision Medicine – which enables clinicians to match medical treatments to the individual characteristics of each patient – will be transformative in the way that healthcare is delivered in future.

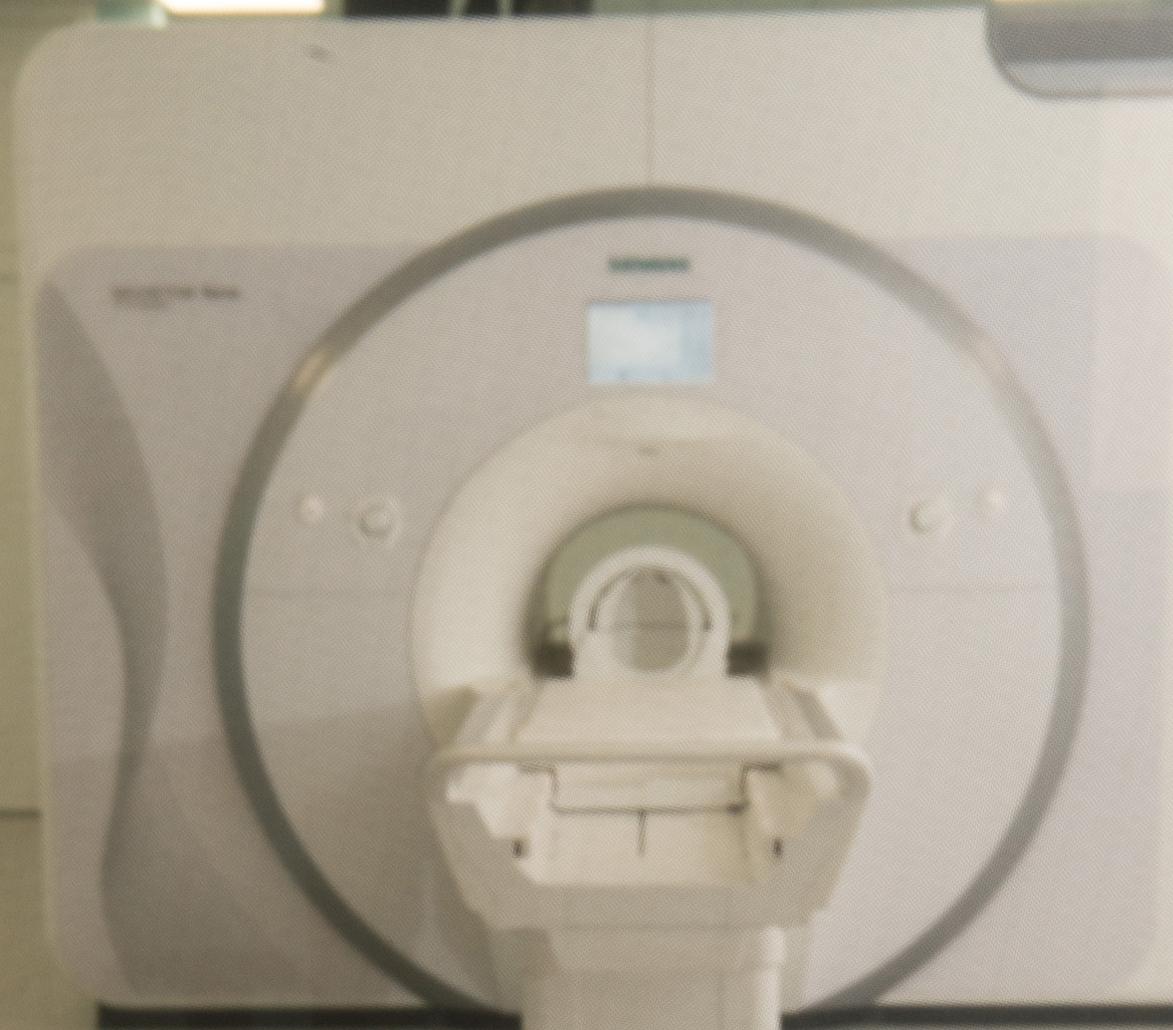


Precision medicine is important to patients because it offers the promise of better outcomes, less side effects and reduced costs. But it also offers opportunities for a wide range of stakeholders. It is of interest not only to scientists and medical professionals, but provides opportunities for industry, academia, health charities, the NHS and governments to collaborate to tackle the significant healthcare challenges that we face.

This important Science & Innovation Audit evidences the wealth of expertise and capabilities that Scotland has, underpinning its leadership in precision medicine. Scotland's well-established Ecosystem for Precision Medicine, centred around the Scottish Government's investment in the Stratified Medicine Scotland Innovation Centre and the Queen Elizabeth University Hospital, the combination of world-class clinical research, high quality electronic health data, patient samples, a single healthcare provider (NHS Scotland), and large cohorts of patients with chronic disease differentiates Scotland from many other countries.

This Audit also outlines the actions and 'game-changing opportunities' which will allow Scotland to realise the full potential of precision medicine, with estimated cumulative health savings which could amount to £70 billion over fifty years as well as economic gains through the creation of a knowledge based economy. Precision medicine promises to deliver both patient and economic benefit for Scotland, and Scotland should now do all it can to realise that promise.

Dr Victor Dzau, President of US National Academy of Medicine



Introduction

1. In autumn 2015, the UK Government announced regional Science and Innovation Audits (SIAs) to catalyse a new approach to regional economic development. SIAs enable local consortia to focus on analysing regional strengths and identify mechanisms to realise their potential. In Scotland, a consortium was formed in 2017 to focus on our strengths in Precision Medicine (PM). This report presents the results which includes a broad-ranging analysis of Scotland's capabilities, the challenges and the substantial opportunities for future economic growth.
2. This SIA report has been developed by an impressive consortium comprising public and private sector partners from across Scotland, as well as a number of leading international actors involved in PM globally. As described by the First Minister of Scotland in her foreword, the SIA process has very much been characterised by a genuine 'Team Scotland' approach, with support, commitment and real insight from industry (both large and small), academia, NHS Scotland, Scottish Enterprise, Scottish Government and the health charities sector operating across the country.
3. The SIA Steering Group includes a wider range of national and international experts from industry, academia, NHS and Government. These include: Professor Dame Anna Dominiczak, Vice-Principal and Head of College of Medical, Veterinary & Life Sciences at the University of Glasgow (Chair); Dr Victor Dzau, President of the US National Academy of Medicine; Peter Silvester, Senior Vice President of Thermo Fisher Scientific; Dr Menelas Pangalos, Executive Vice President of AstraZeneca; Dr Ken Sutherland, President of Canon Medical Research Europe Ltd; Dr David Sibbald, Chair of the Stratified Medicine Scotland Innovation Centre; and John Brown, Chair of NHS Greater Glasgow & Clyde Health Board and NHS Tayside Health Board. A full list of the SIA Steering Group members is included in Annex A.
4. Over recent months, partners have enthusiastically joined together to progress this SIA, ensuring that it provides a robust, balanced and granular assessment of Scotland's PM strengths and emerging prospects for growth. The evidence suggests that the further development and adoption of PM will potentially be transformative for the Scottish and UK life science clusters, developing expertise and know-how that can be exported around the world through new technologies, products, services and behaviours. Indeed, one of the key drivers for the audit has been a recognition across consortium members that Scotland is extremely well positioned to unlock the exciting and substantial productivity growth opportunities associated with PM.
5. The growth and development of Scotland – and indeed the wider UK's - PM ecosystem and associated digital and life science clusters, is only one of the economic benefits. Implementation of PM will help our NHS to generate significant savings at a time when it is struggling to meet increasing demand from an ageing population. Analysis conducted by health economists at the University of Glasgow reveals that PM generated innovations could help deliver billions of pounds of healthcare cost savings. Furthermore, more effective targeted treatments and better prevention of disease will create a healthier and more productive UK workforce.
6. The SIA has ensured we are fully cognisant of the nature and scale of the challenges in translating our research and clinical excellence into a globally significant PM business cluster in Scotland. A review of the evidence collated through this SIA work confirms that most of the key elements of our ecosystem are already in place – and we are well on our way to creating a healthier and wealthier Scotland.

What is Precision Medicine?

7. According to the WISH Precision Medicine Forum, Precision Medicine is defined as:

“the tailoring of medical treatment to the individual characteristics of each patient... to classify individuals into subpopulations that differ in their susceptibility to a particular disease or their response to a specific treatment... allowing preventative or therapeutic interventions to be concentrated on those who will benefit, sparing expense and side effects for those who will not”.¹

8. PM offers business, clinical and social opportunities for a range of stakeholders. It is not only of interest to scientists and medical professionals, but provides a clear space for industry, academia, health charities, the NHS and governments to collaborate to tackle the significant healthcare challenges that we face. There are a number of key market and technology drivers of change impacting on the PM opportunity, including an ageing population, increasing costs of healthcare and the emergence of new technologies (which are converging rapidly) allowing us to develop better, more targeted and tailored healthcare solutions for both economic and patient benefit.

The SIA area

9. This SIA covers the whole of Scotland. The opportunities to grow the PM cluster in Scotland will build on existing clinical, research and commercial expertise in the four major cities (Aberdeen, Dundee, Edinburgh and Glasgow). Scotland is already widely recognised as one of the key life science clusters in Europe², and as demonstrated in a Wave 1 SIA, the Edinburgh city region is a global centre of excellence for computer science and informatics. Through this SIA, we have started to explore how best to leverage the expertise set out in the Edinburgh city region SIA on Data Driven Innovation and develop new collaborative action areas designed to unlock new synergies and associated growth opportunities for the benefit of Scotland and the UK's life science industry as a whole.
10. The core approach that the consortium has adopted in undertaking this SIA has been to demonstrate the scale and nature of the PM opportunity to the whole of Scotland. Whilst Edinburgh and Glasgow boast a wide range of clinical medicine expertise, Dundee has strengths in drug discovery and Aberdeen has expertise in bio-pharmaceuticals. The role of NHS Scotland is also critical in scaling up the PM cluster - both as a key innovation partner and customer - and its remit covers the whole of the country. Indeed, as Scotland's fully integrated healthcare provider, NHS Scotland works closely with industry, academia and the health research charities sector. It provides co-ordinated access to clinical investigators and patients through a single point of contact for industry, accessible clinical research support infrastructures, and streamlined and timely clinical trial approvals.

Our vision

11. The high calibre SIA consortium of public and private partners from across Scotland and international experts are committed to helping Scotland become a global centre of excellence for the implementation of PM over the next 10 years. In order to achieve this vision, the SIA focuses on four main opportunity areas:
- The £1bn Queen Elizabeth University Hospital (QEUH) campus in Glasgow is acting as a focal

¹World Innovation Summit for Health (WISH) (2016) Precision Medicine, A Global Action Plan for Impact – Report of the WISH Precision Medicine Forum

²See for example: Science Business/Sanofi (2015), 'The leading life sciences clusters in Europe'

point for Scotland's wider ecosystem for PM, delivering substantial clinical and economic benefits to Scotland and the UK

- Driving increased awareness and adoption of PM, as well as the strengthening of our innovation ecosystem, will accelerate productivity growth and improved patient outcomes
- Enhancing Scotland's leadership role in the advancement of PM will help to speed up the adoption of PM, providing an internationally significant UK exemplar, attracting Foreign Direct Investment (FDI) and delivering competitive advantage for the UK
- Scotland's PM strengths have the potential to add significant economic value by complementing and synergising with other major UK innovation initiatives; including those in adjacent sectors most notably drug discovery. Specifically we will build on existing close relationships with the UK based European Lead Factory and the Medicines Drug Discovery Catapult. PM will lead to much better understanding of molecular mechanisms of diseases and therefore is prime source of new druggable targets.

Key strengths

12. In recent years, Scotland has built strong foundations, which support the development and diffusion of PM focused approaches to healthcare. Major investments have been made at the new £1bn QEUH campus in Glasgow, including the Stratified Medicine Scotland Innovation Centre (SMS-IC), the Clinical Innovation Zone and the Imaging Centre of Excellence (ICE). This is the first clinical-academic industry campus worldwide designed around the clinical implementation of PM and it is one of the jewels in the crown of Scotland's burgeoning ecosystem for PM. In 2016, the UK's first 7-Tesla (7T) MRI scanner in an acute clinical setting was installed at ICE. Only 75 7T scanners exist worldwide and the Glasgow scanner is one of the first with the capability for use in clinical practice.
13. We have a well-established Scotland-wide Ecosystem for Precision Medicine, centred around the SMS-IC, which is funded by the Scottish Government/Chief Scientist Office (CSO) and industry. The combination of world class clinical research, high quality patient data, patient samples, a single healthcare provider (NHS Scotland), and large cohorts of patients with chronic disease, differentiates Scotland from other life science clusters. Scotland is already widely recognised as a key location for hosting clinical trials and has strong relationships with the global pharmaceutical industry.

ReproCELL Europe is headquartered at the West of Scotland Science Park in Glasgow. It is a contract research services company that works with 19 out of the 20 major global pharmaceutical companies. ReproCELL invested in Scotland in 2015 when it acquired Biopta, a spinout from Glasgow Caledonian University. A new company ReproCELL Europe was then created in 2016, merging Biopta and another acquisition, Reinnervate. ReproCELL Europe currently has 23 employees, with 19 in Glasgow and 4 in County Durham. Its annual turnover is around £1.5m and 90% of sales are exports.

Working with NHS, academic and industry partners at the SMS-IC has helped ReproCELL to improve the selection of patient stratification criteria based on a combination of genomics and associated functional data from studies in human tissue samples. The project was a key factor in ReproCELL's decision to buy Biopta and has also been successful in showcasing the opportunities of industry, academia and the NHS (the triple helix model) working together in the area of Precision Medicine.



14. Scotland's investment in PM has been recognised internationally. In a report for the World Innovation Summit for Health (WISH), Dr Victor Dzau (President of US National Academy of Medicine) highlighted Scotland as an exemplar in terms of cross sector collaboration and the important roles being played by SMS-IC, the Scottish Genomes Partnership, Generation Scotland, and Glasgow Polyomics³.
15. The strength of the PM ecosystem was also recognised by AstraZeneca, when SMS-IC was invited to join its Global Genomics Initiative. In addition, the Universities of Edinburgh and Glasgow have partnered to establish the Scottish Genomes Partnership (SGP). Professor Andrew Biankin, at the University of Glasgow, has led the formation of the International Cancer Genome Consortium (ICGC) Accelerating Research Genomic Oncology (ARGO) project, which is analysing biospecimens from over 100,000 cancer patients worldwide with standardised methods and high quality clinical data.
16. Scotland's key strengths in PM are summarised in Table 1.

ThermoFisher
SCIENTIFIC

Thermo Fisher Scientific Inc. is a global leader in serving science, with a total revenue of more than \$20bn. It supplies instruments, equipment and software, as well as services and consumables to help conduct research, solve complex analytical challenges, improve patient diagnostics, deliver medicines to market and increase laboratory productivity. Around 850 of Thermo Fisher's 70,000 global employees are based in Scotland: 700 at Inchinnan near Glasgow, 100 in Perth, and 50 who are field based. Thermo Fisher generates approximately \$1bn revenue from Scottish customers.

In 2015, a new £14m facility was opened to use Thermo Fisher's proprietary technology to manufacture dry media powder, which is then used to manufacture a range of drugs. One of only two such plants in the world, products from Inchinnan are used by customers across the Europe, Middle East and African (EMEA) markets. These customers then develop drugs that can be used to treat targeted groups of patients. The company was also a founding partner in the SMS-IC.

³Dzau et al (2016), Precision Medicine, A Global Action Plan for Impact -Report of the WISH Precision Medicine Forum 2016



Table 1: Scotland's key strengths in Precision Medicine – an overview

Scotland's unique strengths and key assets	Globally significant PM research base	Expanding PM business base
<ul style="list-style-type: none"> Queen Elizabeth University Hospital (QEUH) – the new £1bn hospital campus opened in 2015 and is the largest acute hospital in the UK. It is home to major specialist services such as renal medicine, transplantation and vascular surgery, with state-of-the-art critical care, theatre and diagnostic services Imaging Centre of Excellence (ICE) - located in the QEUH campus, the centre hosts an ultra high-field 7T MRI scanner, a 3T MRI scanner and a 320 multi-slice CT scanner and houses clinical academic and industry personnel dedicated to the development and deployment of next generation imaging Stratified Medicine Scotland Innovation Centre (SMS-IC) – based within the Clinical Innovation Zone at QEUH, SMS-IC was set up in 2013 as a partnership between four Scottish NHS Health Boards, four Scottish Universities and two industrial partners in informatics - Aridhia Ltd - and in genomics with ThermoFisher Scientific Ltd 	<ul style="list-style-type: none"> Quality of Scotland's electronic health records – among the world's best and include a Community Health Index (CHI) number, which was introduced over 30 years ago and uniquely identifies a person on the index. Data on Scotland's entire population is captured routinely at all points of contact with the health service, meaning patient demographics and clinical information can be readily accessed for clinical research and trials Scotland has the ability to bring together real patient data, historic data and patient samples, as well as unique patient databases such as SHARE and Generation Scotland Single healthcare provider – NHS Scotland is made up of only 14 regional health boards and patient records and regulation is consistent across Scotland 	<ul style="list-style-type: none"> Growing life sciences cluster – Scotland is one of the largest life science clusters in Europe. It employs over 37,000 people across 700 organisations, and contributes around £2bn in annual Gross Value Added (GVA) for the Scottish economy. There has been significant growth in the sector with GVA increasing 45% between 2010 and 2015, and employment growing by 16%^{6,7} Regarded as one the best locations for the developments and clinical trials of treatments and therapies – high number of trials taking place compared to other countries with eight out of the top 10 global CRO's located in Scotland Increasing number of businesses involved in PM – including Canon Medical Systems, Aridhia, Fios Genomics, Pharmaceuticals, Sistemic, Destina Genomics, Bioptra (ReproCELL), BioClavis, ThermoFisher Scientific and Arrayjet Overall, it is estimated by Scottish Enterprise that there are currently around 230 companies undertaking PM related activity in Scotland⁸
<ul style="list-style-type: none"> Scotland's universities produce world-class research and perform well across various international rankings – five of Scotland's universities are in the world's top 200 in the categories of clinical, pre-clinical and health, life sciences and computer science⁴ The quality of research from the four SMS-IC partner universities in PM-related subjects is higher than in other key university groupings in the UK⁵ Key figureheads driving Precision Medicine in Scotland – Professor Dame Anna Dominiczak, Vice-Principal and Regius Chair of Medicine and Therapeutics at the University of Glasgow, and Professor Andrew Morris of the University of Edinburgh and the Farr Institute are at the forefront of developing the PM Ecosystem in Scotland SMS-IC projects showcasing Scotland's expertise – demonstrating the applicability of PM in a range of chronic diseases, and including large multinational consortium projects 		

Scotland's unique strengths and key assets	Globally significant PM research base	Expanding PM business base
<ul style="list-style-type: none"> • MRC/ EPSRC Molecular Pathology Nodes – two of the six UK nodes are based in Glasgow (the UK's largest) and Edinburgh. The nodes provide infrastructure and expertise to deliver PM in a wide range of disease areas 	<ul style="list-style-type: none"> • In 2016, SMS-IC joined AstraZeneca's Global Genomics Initiative. Other partners include the University of Cambridge, the Wellcome Trust Sanger Institute, Genomics England, Human Longevity Inc. in the USA, Columbia University in Canada and Finland's Institute for Molecular Medicine 	<ul style="list-style-type: none"> • Strengthening links between life science companies and Scotland's emerging data and informatics sector – strong strategic focus on health informatics in Edinburgh and Glasgow, making links with Edinburgh City Region SIA
<ul style="list-style-type: none"> • NHS/ University Clinical Research Facilities and accredited Clinical Trials Units – coordinated facilities in Aberdeen, Dundee, Edinburgh and Glasgow bringing together university and NHS Scotland research expertise 	<ul style="list-style-type: none"> • SMS-IC partners are looking to enhance Scotland's expertise in bioinformatics, next generation sequencing, data assimilation, biomarker identification and diagnostics development 	<ul style="list-style-type: none"> • Supportive business environment for start-ups and growth companies – support for firms provided by Scotland's enterprise agencies (Scottish Enterprise, Scottish Development International, Highlands and Islands Enterprise, Skills Development Scotland, Scottish Funding Council) and through private sector investors (e.g. Epidarex Capital)
<ul style="list-style-type: none"> • NHS Research Scotland – encourages researchers to bring studies to Scotland, and invests in nationwide clinical research infrastructure 	<ul style="list-style-type: none"> • Complementary expertise in health economics – University of Glasgow's Health Economics and Health Technology Assessment team (HEHTA) is at the forefront of developing robust economic models on the effectiveness of PM, and the University of Aberdeen Health Economics Research Unit won the Queen's Anniversary Prize for sustained research excellence. 	<ul style="list-style-type: none"> • Broad range of business accommodation tailored to life science and technology rich companies – with key concentrations of sites in the Edinburgh and Glasgow areas (Clinical Innovation Zone, BioCity, BioQuarter)
<ul style="list-style-type: none"> • NHS Scotland Biorepositories and Safe Havens – a network of four regional biorepositories for tissue samples and health data 'safe havens' located in Aberdeen, Dundee, Edinburgh and Glasgow. 		

Source: Precision Medicine in Scotland SIA Consortium

⁴ Times Higher Education World University Rankings

⁵ Based on SQW analysis of SciVal citation impact scores 2014-17 – SMS-IC universities were compared with N8 Research Partnership, Russell Group and Golden Triangle

⁶ Sciences in Scotland (2017), Life Sciences Strategy for Scotland 2025 Vision - Accelerating Growth, Driving Innovation

⁷ The Office for Life Sciences also produces data on the life sciences sector across the UK. The latest data in the 'Strength and Opportunity 2017' report estimates there are just over 15,000 jobs in Scotland in the biopharma and medtech sub-sectors. The SIA consortium agreed that the wider Scottish Government definition of the life sciences cluster was more appropriate to use for the purposes of this Audit

⁸ Analysis undertaken by Scottish Enterprise

Growth opportunities

17. There are several market and technology drivers of change impacting on PM including an ageing population, increasing healthcare costs and the emergence of new disruptive technologies. Changes to regulation, approvals processes, new business models in the pharmaceuticals sector, and growing demand for non-invasive and personalised treatments are also important contextual developments for PM.
18. The global PM market value was estimated at almost \$43bn in 2016 and this figure is projected to rise to around \$134bn by 2025, so it is a prize worth pursuing for both the Scottish and wider UK economies⁹. However, there are significant global challenges in implementing PM in terms of data privacy, the integration of health datasets, regulation, and evidencing impact. Despite these hurdles, the SIA evidence suggests that Scotland has the complementary expertise in clinical research, computer science and informatics needed to create substantial economic opportunities from exploiting PM.
19. More specifically, there are three main areas of economic opportunities from investing in PM in Scotland:
 - It will create new business opportunities in a range of sectors including life sciences, data analytics and informatics, and over 200 Scottish firms are already involved in this area.
 - Implementing PM will help our NHS to generate significant savings at a time when it is struggling to meet increasing demand. Initial analysis by health economists at the University of Glasgow demonstrated how PM generated innovations could help deliver billions of pounds of health savings across Scotland.
 - More effective treatments and better prevention of disease will create a healthier and more productive UK workforce.

Gap analysis

20. The development of this SIA has involved extensive consultation with 45 public and private sector organisations from across Scotland. These in-depth discussions have been used to clarify the existing PM related strengths of Scotland and helped partners to identify where more can be done. The main gaps and solutions are as follows:
 - **Limited integration of, and exploitation of potential synergies across, Scotland's expertise in clinical medicine and data science, both in terms of research and commercial activities. This is a major missed opportunity for the UK**
 - > **Develop a more strategic partnership between clinical medicine and data science capabilities**, including machine learning and artificial intelligence (AI) and the opportunities enabled by new 5G data networks – building on the work of SMS-IC and Datalab, and other joint research, PM offers a major opportunity for closer collaboration between the Universities of Edinburgh and Glasgow, along with NHS Scotland, industry and the major health research charities
 - **Low levels of entrepreneurship in Scotland, compared to other parts of the UK, and a relatively limited number of start-ups to date targeting the PM opportunity**
 - > **Embed a more pervasive culture of enterprise and attract more Venture Capital (VC)**

⁹Frost & Sullivan (2017), Global Precision Medicine Growth: Opportunities, Forecast to 2025. Strategies and Tactics for Accelerating Growth in a Transforming Market

Funds to support the commercialisation effort – we need to promote the PM opportunities for new tech start-ups, celebrate the successes that we have in Scotland, and ensure that growth finance is available (on attractive terms) for investable propositions

- **Inconsistent messaging across Scotland about the scale and nature of the business growth opportunities linked to PM** for start-ups, existing SMEs, and potential inward investors. This has resulted in a lack of clarity and general awareness amongst the business and investor communities
 - > **Create PM champions within NHS Scotland, academia and the Scottish Government**, to work together and with the enterprise agencies and industry to drive demand/investment and raise the profile and awareness of PM related opportunities. A clearer demand statement from NHS Scotland and the Scottish Government would accelerate the development, adoption and mainstreaming of PM in Scotland
 - > Complementing the previous action area, **better PM promotion to the SME base and potential inward investors** – the partners involved in developing this SIA are committed to working with different sectors and investors to articulate the scale and nature of Scotland's offer and the exciting market opportunities associated with PM
- **Insufficient promotion of Scotland's existing key PM assets and centres of excellence** – there needs to be greater clarity on the PM offer and the major investments in new facilities over recent years. A more coherent, powerful and compelling narrative is needed around the PM ecosystem in Scotland and its key differentiators
 - > Encourage **stronger collaboration between key PM assets and centres of excellence** (e.g. the Clinical Innovation Zone at QEUH, BioCity and the Edinburgh BioQuarter etc.), with support from Scottish Enterprise, ensuring a fully integrated offer combining both hard and soft enabling infrastructures
- **Lack of clarity on the skill-sets required to grow and develop the PM cluster in Scotland**
 - > Invest more in targeted PM and bioinformatics and AI for Health skills development programmes – the integration of different skill-sets will be key to developing and maximising Scotland's PM opportunity

Key ambitions and investment proposals

21. Building on the evidence and feedback from SIA Steering Group members and framed by the potential high-level benefits outlined above, we have identified the following key action areas for Scotland to maximise its existing and emerging strengths in PM:

- **Integrate complementary regional strengths in data science and PM** – Scotland now has a potentially transformational opportunity to combine the regional strengths in data science and PM, particularly in Edinburgh and Glasgow, to accelerate the implementation of PM and achieve long term economic impacts for Scotland through NHS savings, a healthier and more productive workforce, and growing Scotland's PM focused business base
- **Develop the QEUH as a 'living lab' to realise the potential of PM and drive economic growth** – the new hospital campus provides an exciting and timely opportunity to pilot the adoption of PM within the UK's largest health board. This will enable the scalable Real World implementation of PM, demonstration of savings to the NHS and patient benefit by the use of health economics, and accelerating the growth and development of the flagship PM cluster in Scotland, creating high value jobs in Govan, an area of historic high unemployment and disadvantage

- **Create next generation clinical decision support tools or ‘clinical cockpits’** – these tools will be developed by making use of Scotland’s enviable access to large databases of relevant patient data (with governance through Scotland’s Safe Havens) to allow the relevant models of population based precision pathways of care to be built. They will also involve clinicians to guide the design and development of these next generation clinical cockpits, and will utilise advances in AI. These tools will be applicable elsewhere in the UK and by other global care providers
- **Develop SMS-IC as a gateway to ‘Scotland’s Ecosystem for PM’** – broadening out the initial work undertaken by the SMS-IC, to encompass other tools for PM such as omics, imaging and digital pathology, work with the NHS on the regulatory aspects and implementation of PM, strengthen the application of health economics and build stronger links with global pharmaceutical and diagnostics firms



BioClavis is a personalised diagnostics spin-out of US based BioSpyder Technologies. In early 2018, BioClavis set up at the Queen Elizabeth University Hospital (QEUH) campus in Glasgow supported by a £3.4m R&D grant from Scottish Enterprise. The parent company BioSpyder was set up in 2011 and developed a novel product for targeted sequencing called TempO-Seq™, a transcriptomic/ genomic platform technology. It has five employees in Glasgow.

BioSpyder considered a range of locations around Europe (in the UK, Ireland, Germany, Switzerland, Netherlands) but soon realised the QEUH in Glasgow was the best location for setting up BioClavis. The first key attractor was the scale and quality of clinical data and samples that they would be able to access. QEUH has one of the largest pathology laboratories in the UK and Europe, and a large biorepository, which is networked to others across Scotland. The company also saw the networking infrastructure as a real asset of Glasgow, specifically the integration of industry, academics and clinicians at the Clinical Innovation Zone.

Networking and collaborating

22. The development of this SIA has been shaped by an open, inclusive and wide-ranging programme of stakeholder engagement and consultation. This has included consultations with 45 stakeholders, in-depth case study research to showcase examples of PM excellence and knowledge exchange on the ground, regular meetings with the SIA Delivery Team, as well as continuous ‘check and challenge’ provided by the high-level SIA Steering Group.
23. We are at the start of an exciting process to scope, define and implement the key growth opportunities for Scotland in the context of a rapidly evolving and highly competitive global PM landscape. Informed by these SIA findings - and indeed the two previous Scotland SIAs, which focused on enabling technologies and data driven innovation - consortium partners are now much better equipped to focus their effort and investment on those niche areas where Scotland is either currently leading the world or has the potential to do so over the next 10 years.

24. The process of developing this SIA has increased the profile and understanding of Scotland's areas of comparative advantage for both internal (Scottish) stakeholders and wider UK and international partners. There is now a clearer understanding of the PM opportunity within the Scottish Government and its agencies. The SIA foreword provided by Scotland's First Minister reflects this strong policy support, and plans are being developed for Scotland to host an international 'Summit in Precision Medicine', to showcase Scotland's highly differentiated and internationally significant PM focused capabilities.
25. Importantly, our consortium is confident and bold enough to know that competitor areas elsewhere in the UK and beyond are also moving fast in relation to PM innovation and adoption. Therefore, we are already using the SIA process and audit report to help us demonstrate to others where and how Scotland can contribute to this exciting global agenda.
26. Indeed, we have a long and proud history of collaborating with the best and we will continue to do this where there are clear complementarities and strong alignment with our strategic objectives. For instance, constructive discussions with the Northern Powerhouse have already taken place and these are giving rise to new partnerships, collaborative ideas and areas of joint working. The partners involved in SMS-IC have also been using the SIA process to highlight Scotland's opportunity and explore new collaborations with partners in Finland and British Columbia in Canada.
27. Encouragingly, the SIA process has energised partners, strengthening their commitment to realise our vision and provided an opportunity for them to foster new relationships across the ecosystem. It has enabled us to shine a spotlight on Scotland's impressive and internationally recognised PM related capabilities. Informed by robust evidence, we have identified a number of targeted new investment propositions designed to complement our existing activities and take us towards our long term goal of translating Scotland's well-established scientific excellence into innovation-led inclusive growth. Many of the pre-requisites for success are in place, but this SIA report has revealed some important gaps which we are determined to fill so we can grow a large and dynamic cluster of exporting frontier companies.



